Ind. Jn. of Agri. Econ.
Vol. 52, No. 3, July-Sept. 1997

Pesticides and the Environment: A Comparative Study of Farmer Awareness and Behaviour in Andhra Pradesh, Punjab and Gujarat

Vasant P. Gandhi and N.T. Patel*

INTRODUCTION

In the debate on the environment and the use of modern technology for raising agricultural production, perhaps the greatest concern is raised with respect to pesticides in agriculture. This input is the only agricultural input which can be highly toxic in nature and, therefore, has the potential for causing direct and substantial harm to human beings as well as the animals and plants that exist in the eco-system. Much has been written about the excessive use of pesticides in the western world, and the substantial harm being caused by them to the environment and human beings (e.g., Carson, 1962; Gino *et. al.*, 1987). It has also been indicated that there may be a pesticide treadmill, in which more pesticides used today will require even more pesticides in the future (Dhaliwal and Singh, 1993; Pastakia, 1996). Many movements have sprung up to discourage the use of chemical pesticides and promote the use of alternative methods of pest control.

On the other hand, control of pests continues to be crucial for the farmers and pesticides play a major role in a large number of crops. The pesticide industry is a dynamic agricultural input industry in India, and with relatively low use levels, has a significant potential for growth (see Gandhi, 1996; Srivastava and Patel 1990; Unni 1997). However, the farmer's behaviour and responsibility in the use of this input is likely to be very important in the future.

To what extent is the farmer aware of the potential dangers of pesticides, how to use them, and the alternatives? How does he evaluate the different methods of pest control? What is his behaviour with respect to use of pest control? These are crucial questions because if any real impact is to be created with respect to pest control and the environment, the farmer knowledge and behaviour are going to be extremely important. This comparative study, across the states of Andhra Pradesh, Punjab and Gujarat, is a modest attempt to examine the awareness of the farmer on environmental issues about pesticides, and the use behaviour in the implementation of pest control.

DATA

The study is based on primary farmer survey data collected from a stratified sample of 216 farmers spread equally over three districts: Guntur district in Andhra Pradesh, Ferozepur district in Punjab and Ahmedabad district in Gujarat. These states were selected because they are among the highest pesticide using states in India and are located in distinctly different agro-climatic regions. Within the states, the districts were selected so as to be able to cover to the extent possible the three major pesticide using crops of cotton, rice and wheat. Cotton

* Faculty Member and Research Associate, respectively, Indian Institute of Management, Vastrapur, Ahmedabad-380 015.

is considered to be the highest pesticide using crop in India (Srivastava and Patel, 1990). Wheat and rice are the most important food crops, and rice is known to have significant pesticide use. Guntur is believed to be the highest pesticide using district in the country. Guntur has 28.4 per cent and 47.6 per cent of the gross cropped area under cotton and rice respectively, but zero per cent under wheat; Ferozepur has 15.3, 23.7 and 44.4 per cent and Ahmedabad has 33.5, 12.1 and 16.3 per cent of the gross cropped area under these three crops respectively (1995-96: respective District Agricultural Offices).

Within each of these districts two to three talukas (or mandals) (eight in all) showing significant presence of cotton, rice and wheat crops were selected. From these, six villages were selected in each district. In each village, 12 farmers were randomly selected and interviewed. Thus a sample of 72 farmers in each district and 216 farmers in all were interviewed using a specially designed questionnaire. Note that the results on Andhra Pradesh are from Guntur district only, and similarly for Punjab - Ferozepur district only, and Gujarat - Ahmedabad district only.

RESULTS

Environment Effects Considered Significant by Farmers

Table 1 presents the results of the survey on the perception of the farmers about the

TABLE 1. FARMER PERCEPTION OF PESTICIDE IMPACT ON THE ENVIRONMENT

(figures in cols. 3 to 6 in per cent)

Impact of pesticides on	Impact: Significant/Not significant	Andhra Pradesh (Guntur)	Punjab (Ferozepur)	Gujarat (Ahmedabad)	Overall	Chi-square across states	Significance
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Labour	Not significant	6.7	4.4	6.9	5.9	2.315	0.314
	Significant	93.3	95.6	93.1	94.1		
Air	Not significant	67.6	79.6	57.4	69.6	33.060	0.000
	Significant	32.4	20.4	42.6	30.4		
Water	Not significant	55.6	78.2	51.4	62.6	58.678	0.000
	Significant	44.4	21.8	48.6	37.4		
Edible agricultural	Not significant	68.9	86.7	30.1	67.0	197.672	0.000
produce	Significant	31.1	13.3	69.9	33.0		
Human beings	Not significant	7.3	3.9	3.7	5.4	6.223	0.045
	Significant	92.7	96.1	96.3	94.6		
Animals	Not significant	16.4	23.8	25.9	21.0	10.443	0.005
	Significant	83.6	76.2	74.1	79.0		

Note: Based on farmer-product responses from a sample survey of 216 farmers spread equally across the three states (districts).

significant impact of pesticides on the environment. This includes the effects on labour, air, water, edible produce, other human beings and animals. The frequencies indicate that the perception about the significant impact on labour is very high (93 to 96 per cent) and there is no significant difference across the states. The perception about a significant impact on air and water, however, are relatively low, ranging from 20 to 49 per cent - being somewhat higher in Gujarat. The perception about a significant impact on edible products is low in Punjab and Andhra Pradesh and significantly higher at 70 per cent in Gujarat. The perception of significant impact on human beings is uniformly high across the states and the same is true for the impact on animals. The difference across the states is statistically significant in all cases except for labour.

It appears from these results that the farmers widely perceive as significant the effects of pesticides on things in their immediate sphere which includes labour, other human beings and animals. However, they do not frequently perceive as significant the effect on the 'outer circle' of air, water and edible agricultural produce.

Awareness and Importance in Decision-making

Table 2 presents the results on the awareness of the farmers about different dimensions of environmental concern with respect to the use of pesticides in agriculture. The results, as above, indicate that on the dimensions of human toxicity and animal toxicity, the

TABLE 2. FARMER AWARENESS AND IMPORTANCE RATING OF DIFFERENT ENVIRONMENT RELATED FACTORS IN PEST CONTROL DECISION-MAKING

Factors	Aware (%) and Importance rating	Andhra Pradesh (Guntur)	Punjab (Ferozepur)	Gujarat (Ahmedabad)	Overall	Chi-square /F-ratio across states	Significance
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Human toxicity	Aware (%)	98.6	100.0	98.6	99.1	1.009	0.604
	Rating (mean)	3.06	2.97	3.00	3.01	0.556	0.574
Animal toxicity	Aware	94.4	100.0	98.6	97.7	5.323	0.070
	Rating (mean)	2.96	2.88	2.93	2.92	0.467	0.628
Environmental harm/concern	Aware	33.3	19.4	86.1	46.3	71.652	0.000
	Rating (mean)	2.29	2.21	2.29	2.29	46.31	0.000
Harm to good insects	Aware	40.3	25.0	95.8	53.7	80.479	0.000
	Rating (mean)	2.17	2.72	3.38	2.97	41.71	0.000
Increasing need for pesticide use	Aware	15.3	8.3	87.5	37.0	118.68	0.000
	Rating (mean)	2.82	2.50	3.05	2.98	0.454	0.637
The correct dosage and harmful effect of excessive use	Aware	4.2	1.4	86.1	30.6	157.22	0.000
	Rating (mean)	3.33	3.00	2.84	2.86	0.249	0.781

(Contd.)

TABLE 2 (*Concld.*)

Factors	Aware (%) and Importance rating	Andhra Pradesh (Guntur)	Punjab (Ferozepur)	Gujarat (Ahmedabad)	Overall	Chi-square /F-ratio across states	Significance
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Harmful effect of pesticide residues in food	Aware(%)	16.7	6.9	1.4	8.3	11.273	0.004
	Rating (mean)	2.58	2.60	3.00	2.61	0.149	0.863
Market restrictions on pesticide residues in food	Aware	1.40	0.0	0.0	0.50	2.009	0.3363
	Rating (mean)	4.00	-	-	-	-	-
Integrated pest management	Aware	0.0	0.0	0.0	0.0	-	-
	Rating (mean)	-	-	-	-	-	-
More environment friendly new product	Aware	0.0	0.0	0.0	0.0	-	-
	Rating (mean)	-	-	-	-	-	-
Biological control of pest	Aware	0.0	0.0	0.0	0.0	-	-
	Rating (mean)	-	-	-	-	-	-
Possibilities for natural home made pest control remedies	Aware	2.8	0.0	0.0	0.90	4.037	0.133
	Rating (mean)	1.0	-	-	-	-	-
Company efforts to promote more or excessive pesticide use	Aware	5.6	0.0	0.0	0.0	8.151	0.017
	Rating (mean)	4.50	-	-	-	-	-
Some of the old products do more damage to environment	Aware	0.0	0.0	0.0	0.0	-	-
	Rating (mean)	-	-	-	-	-	-
Threshold pest population level for application	Aware	0.0	0.0	0.0	0.0	-	-
	Rating (mean)	-	-	-	-	-	-
Importance of safety in spraying	Aware	97.2	100.0	95.8	97.7	2.866	0.239
	Rating (mean)	3.90	2.99	2.94	3.27	38.398	0.000

Note: Importance in decision-making has been rated on a scale of 1 to 5 (Not Important to Very Important) and the results are based only on those who show awareness.

Statistical significance across states evaluated by Chi-square for awareness (%) and F-ratio for rating.

The adoption, therefore, cannot be expected.

awareness is extremely high, with no significant difference across the state samples. The importance rating of these in pest-control decision-making is, however, not very high (about 3 on a scale of 1 to 5). When it comes to environmental harm/concern, the awareness frequencies are sharply lower. There is, also, a significant difference between the states with

the percentages being 33 per cent only in Andhra Pradesh, 19 per cent only in Punjab and 86 per cent in Gujarat samples. On the harm to good insects, the awareness is somewhat higher, but awareness on the increasing need to use pesticides is low except in Gujarat where it is 87 per cent. On the awareness about correct dosage and harmful effects of excessive use, the awareness is very low at 4 and 1 per cent respectively in Andhra Pradesh and Punjab. With respect to the harmful effect of pesticide residues in food and market restrictions on pesticide residues, the awareness is almost nil.

How is the awareness with respect to alternative methods? It is found that the awareness regarding integrated pest management, environment-friendly new products, biological control of pests, and possibilities for natural/homemade remedies is practically nil in all the surveyed districts. Thus the information/awareness about these does not seem to have percolated at all to the farmers. The adoption, therefore, cannot be expected.

With respect to issues such as the threshold pest level population for pesticide application, that some old products are damaging to the environment, and company efforts to promote more or excessive pesticide use, the awareness is also almost none. There is hardly any awareness on selecting less harmful products, and the necessary quantity of pesticide to apply. The awareness about the importance of safety in spraying is, however, almost universal and is given a high importance rating in decision-making.

Awareness, Use and Opinion about Different Methods of Pest Control

Table 3 presents the finding on the awareness, use and opinion on effectiveness about different major methods of pest control. With respect to cultural methods, the awareness is very low ranging from 19 per cent in Andhra Pradesh to 1 per cent in Punjab. The use of this method is even less and ranges from 4 per cent in Andhra Pradesh to none in Punjab. On the use of crop rotation, the awareness is very high, ranging from 84 per cent in Gujarat to 99 per cent in Andhra Pradesh. However, the use of this method is very low in Gujarat and Punjab and high only in Andhra Pradesh at 71 per cent. The awareness about manual control is over 91 per cent in all the states, and its use is 78 per cent in Andhra Pradesh, 54 per cent in Punjab and 32 per cent in Gujarat.

With respect to the use of alternative methods of biological control, home-made formulations, and environment friendly alternatives, not only is the use practically nil, but also the awareness is almost none. Thus despite publicity, hardly any awareness about these seems to have percolated to the farmers.

On the other hand, the awareness about chemical pesticides is 100 per cent in all the states. This is used by 100 per cent of the farmers in Andhra Pradesh and Punjab, and 71 per cent in Gujarat. All these farmers also consider chemical pesticides to be effective. Thus chemical pesticides emerge as the dominant method for pest control. The awareness about seed treatment is above 90 per cent in all states but its use is very little - 4 per cent or less.

TABLE 3. FARMER RESPONSE ON AWARENESS, USE AND EFFECTIVENESS OF DIFFERENT PEST CONTROL METHODS

Pest control technology	Aware/Use/ Effectiveness	Andhra Pradesh (Guntur)	Punjab (Ferozepur)	Gujarat (Ahmeda-bad)	Overall	Chi-square F-ratio across States	Signi-ficance
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Cultural method	Aware	19.4	1.4	6.9	9.3	14.65	0.001
	Use	4.2	0.0	2.8	3.0	17.168	0.009
	Effective	4.2	0.0	2.8	2.3	2.866	0.239
Crop rotation	Aware	98.6	93.1	84.7	92.1	9.705	0.008
	Use	70.8	11.1	5.6	29.2	94.887	0.000
	Effective	70.8	11.1	5.6	29.2	91.294	0.000
Manual control	Aware	94.4	91.7	97.2	94.4	2.118	0.347
	Use	77.8	54.2	31.9	54.6	37.359	0.000
	Effective	77.8	52.8	33.3	54.6	30.940	0.000
Biological control	Aware	1.4	0.0	0.0	0.5	2.009	0.366
	Use	1.4	0.0	0.0	0.5	2.009	0.366
	Effective	1.4	0.0	0.0	0.5	2.009	0.366
Home made formulations	Aware	2.8	0.0	1.4	1.4	2.028	0.363
	Use	0.0	0.0	1.4	0.5	6.028	0.197
	Effective	0.0	0.0	1.4	0.5	2.009	0.366
Environment friendly alternatives	Aware	1.4	0.0	0.0	0.5	2.009	0.366
	Use	0.0	0.0	0.0	0.0	2.009	0.366
	Effective	0.0	0.0	0.0	0.0	-	-
Chemical pesticides	Aware	100.0	100.0	100.0	100.0	-	-
	Use	100.0	100.0	70.8	90.3	46.523	0.000
	Effective	100.0	100.0	70.8	90.3	46.523	0.000
Seed treatment	Aware	98.6	95.8	94.4	96.3	1.817	0.403
	Use	4.2	0.0	4.2	2.8	4.878	0.300
	Effective	4.2	0.0	4.2	2.8	3.089	0.213

Note: The percentage figures are based on % farmers aware, % who use and % who consider it effective.

Use of Pesticides

Within the use of chemical pesticides, which are used by 100 per cent of sample farmers in Andhra Pradesh and Punjab and 71 per cent of the farmers in Gujarat, what is the pattern of product use over the states? How are these products rated for safety hazard? Table 4 presents the findings on these from the survey. The difference across states is statistically

TABLE 4. PESTICIDE PRODUCTS USED ACROSS STATES BY FARMERS

(per cent)

Sr. No.	Active ingredient technical name	No. of formula-tions	Safety hazard label (triangle)	Andhra Pradesh (Guntur)	Punjab (Ferozepur)	Gujarat (Ahmed-abad)	Overall
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1.	Acephate 75% SP	3	Blue	4.0	0.5	0.0	2.0
2.	Aldrin 30% EC	1	Red	0.0	0.0	25.1	3.9
3.	Butachlor 50% EC	2	Yellow	0.2	0.0	0.0	0.1
4.	Benzil-Thiophosphate 48% EC	1	Blue	0.2	0.0	0.0	0.1
5.	BPMC-Fenobucarb 50% EC	1	Yellow	0.4	0.0	0.0	0.2
6.	BHC 50% WP	2	Yellow	0.0	0.4	1.9	0.5
7.	Carbandazim 85% D	3	Blue	3.9	0.0	0.0	1.7
8.	Cypermethrin 25% EC	2	Yellow	10.0	0.0	0.5	4.4
9.	Cypermethrin 10% EC	1	Yellow	6.7	11.4	0.0	7.6
10.	Chlorpyriphose 20% EC	3	Yellow	4.6	0.0	6.3	2.9

(Contd.)

TABLE 4 *(Concld.)*

Sr. No.	Active ingredient technical name	No. of formula-tions	Safety hazard label (triangle)	Andhra Pradesh (Guntur)	Punjab (Ferozepur)	Gujarat (Ahmed-abad)	Overall
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
11.	Chlordane 20% EC	1	Yellow	0.2	0.0	0.0	0.1
12.	Copper-Oxychloride 50% WP	1	Blue	0.4	0.0	0.0	0.2
13.	Dimethoate 30% EC	2	Yellow	8.4	19.8	8.7	13.2
14.	DDVP 76% EC	1	Yellow	0.4	0.0	1.0	0.3
15.	Decamethrin 2.8% EC	1	Yellow	0.2	0.0	0.0	0.1
16.	Endosulfan 35% EC	4	Yellow	8.9	7.1	5.8	7.7
17.	Ethion 50% EC	2	Yellow	1.8	0.0	0.0	0.8
18.	Fenvalerate 20% EC	2	Yellow	2.5	11.5	8.7	7.2
19.	Glyphostate 41% SL	1	Blue	0.2	0.0	0.0	0.1
20.	Monocrotophos 36% WSC	2	Red	23.3	33.7	23.2	27.6
21.	Mancozeb 75% WP	3	Green	4.9	0.7	0.5	2.5
22.	Methyl Demetone 25% EC	1	Yellow	2.1	2.0	0.0	1.7
23.	Methyl Parathion 50% EC	1	Red	0.0	0.7	0.0	0.3
24.	Phorate 10% G	1	Red	1.2	4.8	11.6	4.3
25.	Phosolone 35% EC	1	Yellow	-	-	-	-
26.	Phosphomidon 85% WSC	2	Red	0.5	0.0	3.9	0.8
27.	Quinalphos 25% EC	1	Yellow	11.9	6.2	0.5	7.8
28.	Sulphur 85% D	1	Green	0.5	0.0	0.5	0.3
29.	Sulphur 80% WP	1	Green	0.5	0.2	0.0	0.3
30.	Streptomycin Sulphate 90% WP	1	Green	0.2	0.0	0.0	0.1
31.	Tricyclozoie 85% WP	1	-	0.2	0.0	0.0	0.1
32.	Zinc-Phosphide 50% WP	1	Red	0.7	0.2	0.0	0.4
33.	Pretilachler	1	Yellow	0.2	0.0	0.0	0.1
34.	Zinc-EDTA	1	-	0.7	0.2	0.0	0.4
35.	(Bina)	1	-	0.2	0.0	0.0	0.1
36.	(Microfted)	1	-	0.2	0.0	0.0	0.1
37.	Weedicide	-	-	0.0	0.7	1.9	0.6
38.	Neemoil	1	-	0.5	0.0	0.0	0.2

Chi-square = 737.89; Significance = 0.000.
Note: Based on farmer-crop-product application data.

significant - indicating highly different patterns of use across the states (districts). No single chemical seems to dominate the market. However, Monocrotophos 36 % WSC, Dimethoate 30 % EC, Endosulphan 35 % EC, and Cypermethrin 10 % EC emerge as the major chemicals with 27.7, 13.2, 7.7 and 7.6 per cent shares respectively in the reported frequency of farmer-crop application reporting. They together, therefore, constitute over 50 per cent of the share in the reporting.

What is the distribution of pesticide application from the safety point of view? This is evaluated in Table 5. The table indicates that the use of extremely hazardous and highly hazardous chemicals by farmers, which form the top of the hazard band, is extensive. The red triangle label (extremely hazardous) chemicals have a share of 26 per cent in Andhra Pradesh, 39.7 per cent in Punjab and as high as 65 per cent in Gujarat of the reported farmer-crop use. The yellow triangle label (highly hazardous) group constitutes 59 per cent both in Andhra Pradesh and Punjab and 34 per cent in Gujarat of the reported use. The less hazardous groups are used to a very limited extent. The differences are statistically significant across the states. Thus the profile of pesticide use is oriented substantially towards the extremely hazardous and highly hazardous chemicals.

TABLE 5. FARMER PESTICIDE USED BY HAZARD LEVEL

(per cent)

Sr. No.	Official label colour	Hazard level	Andhra Pradesh (Guntur)	Punjab (Ferozepur)	Gujarat (Ahmed-abad)	Overall
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1.	Green	Slightly hazardous	6.2	0.9	1.0	3.2
2.	Blue	Moderately hazardous	8.7	0.6	0.0	4.0
3.	Yellow	Highly hazardous	59.0	58.9	34.0	55.0
4.	Red	Extremely hazardous	26.1	39.7	65.0	37.8
		Chi-square = 163.57.				
		Significance = 0.000.				

Source: Iyer (1995).
Note: Based on farmer-crop-product use.

Some Determinants of Pesticide Use Behaviour

A limited attempt has been made to examine the determinants of pesticide use behaviour of the farmers. The behaviour is expected to be related to determinants such as land owned, land irrigated, area under cotton, area under rice, area under wheat, age of the farmer and education of the farmer and location, on which information is available. The following model is used to examine the pesticide use behaviour.

$$\text{Pesticide use} = a + b_1\,\text{LANDTOT} + b_2\,\text{LANDIRRG} + b_3\,\text{ACOTTON} + b_4\,\text{ARICE} + b_5\,\text{AWHEAT} + b_6\,\text{AGE} + b_7\,\text{EDUC} + b_8\,\text{DAP} + b_9\,\text{DPUN} + e$$

where

LANDTOT = total land owned (acres),
LANDIRRG = total land irrigated (acres),
ACOTTON = area under cotton (acres),
ARICE = area under rice (acres),
AWHEAT = area under wheat (acres),
AGE = age of the main decision-maker in years,
EDUC = education of the main decision-maker
DAP = dummy for Andhra Pradesh (Guntur),
DPUN = dummy for Punjab (Ferozepur),
a, b_i = parameters,
e = error term.

Three different dependent variables have been used to characterise pesticide use: APPLT = total number of applications over the crop year; AREAT = total area covered, COSTT = total cost of pesticide application.

The results are given in Table 6. All the equations show a reasonably good fit for cross-sectional analysis - R^2 are 0.6 and above. On the number of applications equation, the irrigation variable is highly significant, showing irrigation as a strong determinant. The Andhra Pradesh and Punjab dummies are also significant, indicating significantly greater use at these locations, with Andhra Pradesh having a high coefficient. The land owned variable has a negative sign, indicating greater intensity of use on small farms though this is not statistically significant in this equation.

TABLE 6. REGRESSION RESULTS ON FARMER PESTICIDE USE BEHAVIOUR

Eq. No.	Dependent variable		Independent variables										R^2	N
			Constant	LANDTOT	LANDIRRG	ACOTTON	ARICE	AWHEAT	EDUC	AGE	DAP	DPUN		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
1.	APPLT	Coeff.	-0.142	-0.256	0.478	0.344	-0.163	0.166	0.237	0.038	35.562	6.5277	0.652	213
		t-statistic	-0.037	-1.460	2.924	1.292	-0.572	0.740	1.119	0.453	14.316	2.437		
		Signf.		***							***	***		
2.	AREAT	Coeff.	-7.459	-1.265	2.386	2.985	0.737	1.847	0.282	-0.156	20.621	10.155	0.747	213
		t-statistic	-1.045	-5.392	10.897	8.360	1.925	6.137	0.993	-1.387	6.207	2.834		
		Signf.		***	***	***	**	***			***	***		
3.	COSTT	Coeff.	1794.008	128.104	836.273	296.592	-175.987	-197.107	-290.044	-129.943	12363.281	4461.111	0.592	213
		t-statistic	0.523	1.135	7.944	1.727	-0.956	-1.362	-2.124	-2.400	7.742	2.590		
		Signf.			***	*			**	**	***	***		

Note: ***, ** and * Significant at 99 per cent, 95 per cent and 90 per cent respectively.

The area covered equation indicates that cotton area and wheat area are highly significant determinants, with cotton having a high coefficient. Irrigation once again emerges as a significant determinant. Land owned has a negative and highly significant coefficient, indicating intensification of use with small farm sizes. The dummies for Andhra Pradesh and Punjab are also significant and positive, indicating higher use there.

The cost incurred equation shows that the education has a negative and significant coefficient, indicating that more educated farmers spend less on pesticides. Age also has a negative and significant coefficient, indicating that younger farmers (decision-makers) tend to spend more on pesticides. Irrigation continues to have a positive and significant coefficient and the Andhra Pradesh and Punjab dummies are also significant.

CONCLUSIONS

The study has examined farmer perception, awareness and behaviour on the use of pest control technology in agriculture in relation to environmental concerns. It evaluates and compares these across important pesticide using states of Andhra Pradesh (Guntur district), Punjab (Ferozepur district) and Gujarat (Ahmedabad district) through primary data. The study finds that farmer perception of the significant impact of pesticides on the environment seems to exist but is limtied to his immediate surroundings of labour, other human beings and animals. It does not go beyond this to the effects on water, air and residues in the produce. His awareness about these effects as well as when and how to use pesticides is very limited. Further his awareness about environment friendly alternatives such as biological control, integrated pest management and home-made formulations is almost nil. On the other hand, awareness about pesticides is 100 per cent and they are used by 90 per cent of the farmers. Thus it appears that even the awareness about environmental concerns and environmental friendly alternatives has not percolated much to the farmers. The adoption, therefore, cannot yet be expected.

Farmers use a large variety of chemical pesticides and a large number of different active ingredients, but none of these has an overwhelming share. Monocrotophos 36 % WSC, Dimethoate 30 % EC, Endosulphan 35 % EC and Cypermethrin 10 % EC have significant shares in the sample studied. However, the share of highly hazardous and extremely hazardous chemicals is very high in all these three locations, especially in Gujarat.

On studying use behaviour, it was found that pesticide use levels are determined significantly by the extent of irrigation. The levels are also determined significantly by the presence of cotton and wheat in the cropping pattern. Use levels are also related to location, being higher in Andhra Pradesh (Guntur) and Punjab (Ferozepur) as compared to Gujarat (Ahmedabad). The intensity of use is higher on small farms. Education of the farmers seems to reduce the expenditure on pesticides. However, younger farmers appear to spend more on pesticides.

REFERENCES

Carson, Rachel Louise (1962), *Silent Spring,* Houghton Mifflin Company, Boston.

Dhaliwal, G.S. and Balwinder Singh (Eds.) (1993), *Pesticides: Their Ecological Impact in Developing Countries,* Common Wealth Publishers, New Delhi.

Gandhi, Vasant P. (1996), "Growth and Economics of Pesticide Use in India: Overview-Analysis of the Environment, Patterns and Market Potential", Paper presented at the IAAE Symposium on "Economics of Agro-Chemicals", Wageningen, The Netherlands, April 24-27.

Gino, M.J.; R.M. Hollingworth and W. Durham (1987), *Silent Spring Revisited,* American Chemical Society, Washington, D.C., U.S.A.

Iyer, V.N. (1995), "Safety Precautions in Manufacture", in Vasantharaj B. David (Ed.) (1995), *The Pesticide Industry,* Kothari's Desk Book Series, HC Kothari Group, Publications Division, Madras.

Pastakia, Astad R. (1996), *Grassroots Innovations for Sustainable Development: The Case of Agricultural Pest Management,* Ph.D Dissertation, Indian Institute of Management, Ahmedabad (Unpublished).

Srivastava, U.K. and N.T. Patel (1990), *Pesticides Industry in India: Issues and Constraints in Its Growth,* Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.

Unni, K.K. (1997), "Role of Agro-chemical Industry", in B.M. Desai (Ed.) (1997), *Agricultural Development Paradigm for the Ninth Plan Under New Economic Environment,* Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.